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(54) COVERINGS FOR SUBMERSIBLE OR SEMI-SUBMERSIBLE STRUCTURES

(71) We, UNITED WIRE GROUP LIMITED, a British Company, of Granton Park Avenue, Edinburgh EH5 1HT, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to the retardation of marine growth on submersible or semi-submersible structures.

Marine growth, for example slimes, barnacles, tube-worn, molluscs and certain animal organisms such as sponges and anemones, adversely affect such structures and may accelerate corrosion.

On ships the major impact of marine growth is an operating efficiency where a 30% increase in resistance can occur after only one year. This in turn leads to an equivalent increase in power requirements for a constant operating speed or to a loss of speed, for example 3 knots or more on a 15.5 knot tanker. On ships' hulls certain molluscs such as mussels are unable to adhere to the surface of the structures at normal operational speeds. Molluscs do, however, adhere to the surface when the ship travels at low speeds or is at rest. Furthermore, fouling by other growth requires the ship to be put into dry dock at regular intervals for cleaning and re-painting, or at least to be put into a calm site for inwater cleaning of the hull.

Offshore structures such as oil rigs present ideal static surfaces for the attachment and growth of marine organisms. Layers of fouling have been known to increase the overall diameters of members of offshore structures by up to 2 feet, thus increasing wave loading on the structure and making difficult the task of inspection and maintenance particularly of sensitive areas such as nodes.

Outfall pipes, buoys and mooring points can also be seriously affected and removal of fouling from concrete structures can cause surface damage. Unattended sub-sea installations such as well-head completions may be so camouflaged with fouling that they may be extremely difficult to find when required.

It has long been known to use copper to retard or prevent marine growth on structures subjected to sea water. Copper sheets were commonly fixed to the hulls of wooden ships to prevent such growth. However the use of copper sheets is impractical on structures of ferrous metal, for example ships' hulls or fixed off-shore structures, because of the expense of cladding with copper sheets and also because contact between the copper and the structure results in extreme corrosion of the ferrous metal and rapid deterioration of the structure.

More recently it has been common practice to coat the structure with a paint containing copper salts from which the copper ions are released to poison the marine growth. A disadvantage of such a method is that the life of the coating is relatively short and repainting has to be carried out at frequent regular intervals, commonly about every two years.

Other attempts to provide practical marine growth inhibitors for ships have been proposed, but none have so far been commercially successful or applicable to most existing and new submersible or semi-submersible structures.

In accordance with one aspect of the present invention, there is provided a submersible or semi-submersible anti-fouling structure comprising a layer of carrier material and a mesh of copper or copper alloy embedded in said material said mesh being exposed at the outer surface of said layer so as to be accessible to sea water for retarding or preventing marine growth on said structure.

Preferably, the area of exposed mesh is less than 50%, and preferably not greater than

35%, of the total area of the outer surface of the layer.

For most applications a mesh size of 3 to 60 mesh per inch with all the knuckles in one plane on one side of the wire cloth exposed provides good antifouling properties. However it is preferred to have a size of from 6 to 20 mesh per inch. Even if young molluscs, for example, adhere to the covering in the interstices between the exposed knuckles of the larger mesh sizes, they are killed and fall off as soon as they grow sufficiently to touch the metal of the mesh.

In accordance with another aspect of the invention, there is provided an anti-fouling panel for attachment to the surface of a submersible or semi-submersible structure, said panela comprising a layer of carrier material and a mesh of copper or copper alloy embedded in said material, said mesh being exposed at the outer surface of said layer so as to be accessible to sea water for retarding or preventing marine growth on said panel.

The advantage of such panels is that they can be attached in juxtaposition on existing ships or offshore structures. Such attachment is conveniently by using an epoxy resin adhesive after cleaning of the structure surface. Depending on the size of mesh the panels are relatively flexible and can be produced flexible enough to conform to the shape of a ships' hull or to a pipe. The panels may, however, be secured to the structure by mechanical means, for example by tying. The panels may be formed by any suitable means, for example casting, spreading, hot pressing, or calendering. Preferably, the thickness of each panel is between 0.05 mm and 2.00 mm.

The carrier layer is preferably of a plastics material, for example a thermosplastic polymer, such as polypropylene, or a thermosetting polymer, such as a polyester. Such a polymer may be used with a glass fibre reinforcement either as a mat or in the form of random choppings or rovings.

Pure copper or many copper alloys could be used as the material for the mesh, preferably with a copper content of at least 60%. It is envisaged for example that for use in static structures, or for low-speed application, bronze could be used containing, for example, from 95% copper. For higher speed applications, for example on ships' hulls, cupro-nickels could be used, for example approximately a 90/10 alloy with small amounts of iron and/or other elements, the alloy consituents being changed to improve errosion/corrosion properties for increased speed of operation. Other copper alloys could also be used, for example aluminium bronze containing a proportion of copper greater than 99%. It has been found that, generally the greater the copper content of an alloy, the greater its effectiveness in retarding marine growth.

Conveniently, the mesh size is in the range of 3—60 mesh/inches (1.2 —24 mesh/cm.), the wire diameter being of from 0.05 to 1.5 mm. We have discovered that for the reduction of certain marine growth it is desirable to use a mesh size of at least 12 mesh/inch (4.7 mesh/cm.) but considering other factors, such as ease of production and costs, the optimum mesh size is probably in the region of 20 mesh/inch (8.0 mesh/cm.).

Preferably, the mesh is exposed to the sea water at the outer surface, the knuckles preferably protruding through or being level with the outer surface of the carrier material. The knuckles are preferably all in the same plane, so that for a given mesh size and wire gauge more metal is available at the outer surface which is in use subjected to sea water, and are regularly spaced apart. For mesh of pure copper our investigations indicate that the area of exposure of the metal is desirably greater than about 13% of the area of the covering.

Optionally, the carrier material could be applied directly to the structure, for example by spraying the carrier material on to the structure and embedding the mesh in the carrier on the structure.

In order that the mesh may project from the outer surface of the covering and in use be in direct contact with the sea water the panels may be formed with the mesh exposed at the outer surface, or the outer surface may be abraded to expose the mesh.

However, particularly for movable structures the mesh need not be exposed and in direct contact with the sea water but may be coated with a layer of coating material which is permeable to water, preferably a thin coating of plastics material through which the copper can diffuse. The surface coating may take the form of a polyester or epoxy film which may be filled, either with an insoluble material which enhances the water permeability of the layer, such as cotton fibre, wood fibre or wood flour, or with a water soluble material such as copper oxide which would be leached by the sea water to give a porous structure. Optionally, the coating film may be of the same material as the carrier and integral with the carrier.

Two embodiments of the invention will now be described by way of example, with reference to the accompanying drawings in which:—

FIGURE 1 is a diagrammatic view of one form of panel for securing to a submersible or semi-submersible structure, and

FIGURE 2 is a plan view of another form of panel.

Each panel comprises a layer 1 of carrier material in the form of a glass-reinforced polyester and a mesh 2 of copper alloy

embedded therein. The knuckles 3 of the mesh protrude through or are level with the front surface 4 of the layer 1, but are not level with the rear surface 5.

In the panel of Figure 1 the front surface 4 is covered by a thin layer 6 of resin material, filled with cotton fibre or the like, through which sea water can permeate. Optionally, the mesh may be totally embedded in the carrier material 1, a thin layer of the carrier material coating the mesh and being permeable by sea water.

In the embodiment of Figure 2, there is no covering layer 6 and the knuckles 3 are in use in direct contact with the sea water. The knuckles are regularly spaced apart, the distance between adjacent knuckles being from 0.25 to 7 mm.

In use a plurality of such panels are secured to the surface of a structure, for example a ship's hull, with the rear surface 5 being bonded by suitable cement to the structure. Because the copper alloy mesh is insulated from the rear surface 5, there can be no electro-chemical interaction between the mesh and the structure. Furthermore, the carrier material and cement provide a barrier which effectively reduces corrosion of the structure by sea water.

The mesh may be woven or knitted, or may be an expanded metal mesh. In the case of woven or knitted meshes, the copper strands may be interwoven with strands of other material, for example plastics. As an example, the copper strands may all extend in one direction and the plastic strands in the other direction.

In standard woven meshes, half the number of knuckles on one side of the mesh are generally disposed in one plane and the other half are disposed in a different plane, the planes being slightly spaced apart. Thus, considering both surfaces of the mesh, the knuckles lie in four different planes. It is preferred in the present embodiment that the knucles are disposed in a single plane so that all of them project from or are level with the front carrier surface 4. The formation of knuckles in a single plane may be achieved for example by rolling standard meshes or by a suitable weaving process.

During the life of the panel, copper from the mesh dissolves and in the panel of Figure 1 diffuses through the coating layer 6. However, the mesh presents a continuous run of copper alloy which is gradually leached away by the sea water. Thus, the life of the covering may be controlled by suitable choice of the alloy, the mesh size and the diameter of mesh wire, to suit a particular application.

The rate of dispersion of the copper may be further controlled by the application of an electric potential to the mesh, which controls the quantity of copper liberated. Optionally, the mesh may include strands of metal other than copper or copper alloy to control the rate of dispersion. For example, nickel may be interwoven to enhance the toxicity of the covering or zinc may be used to inhibit the toxicity.

The above-described covering has the advantages over copper or copper alloy sheets that it is relatively simple to attach to the structure, that electro-chemical reaction between the structure and the copper is avoided, that emission of the copper can be controlled, and that there is a cost advantage for selected mesh sizes.

WHAT WE CLAIM IS:—

1. A submersible or semi-submersible anti-fouling structure comprising a layer of carrier material and a mesh of copper or copper alloy embedded in said material, said mesh being exposed at the outer surface of said layer so as to be accessible to sea water for retarding or preventing marine growth on said structure.

2. A structure according to claim 1, wherein the area of exposed mesh is less than 50% of the total area of the outer surface of the layer.

3. A structure according to claim 2, wherein said area of exposed mesh is less than 35% of the total area of the outer surface of the layer.

4. A structure according to any of claims 1 to 3, wherein the area of exposure of the mesh is greater than about 13% of the total area of the outer surface of the layer.

5. A structure according to any of claims 1 to 4, wherein the mesh is coated with a layer of coating material which is permeable by sea water.

6. A structure according to claim 5, wherein the coating material is the same as the carrier material and is integral therewith.

7. A structure according to claim 5 or 6, wherein said coating material is a resin filled with a material which is insoluble in water and which enhances the permeability of said coating layer.

8. A structure according to any of claims 5 to 7, wherein said coating material is a resin filled with a material which is soluble in water and which can be leached out in water to provide a porous coating layer.

9. A structure according to any of claims 1 to 8, wherein the mesh is a woven mesh.

10. A structure according to any of claims 1 to 9, wherein the mesh size is in the range of 3 to 60 mesh/inch.

11. A structure according to claim 10, wherein the mesh size is greater than about 12 mesh/inch.

12. A structure according to claim 11, wherein the mesh size is about 20 mesh/inch.

13. A structure according to any of claims 1 to 12, wherein the mesh is formed

embedded therein. The knuckles 3 of the mesh protrude through or are level with the front surface 4 of the layer 1, but are not level with the rear surface 5.

In the panel of Figure 1 the front surface 4 is covered by a thin layer 6 of resin material, filled with cotton fibre or the like, through which sea water can permeate. Optionally, the mesh may be totally embedded in the carrier material 1, a thin layer of the carrier material coating the mesh and being permeable by sea water.

In the embodiment of Figure 2, there is no covering layer 6 and the knuckles 3 are in use in direct contact with the sea water. The knuckles are regularly spaced apart, the distance between adjacent knuckles being from 0.25 to 7 mm.

In use a plurality of such panels are secured to the surface of a structure, for example a ship's hull, with the rear surface 5 being bonded by suitable cement to the structure. Because the copper alloy mesh is insulated from the rear surface 5, there can be no electro-chemical interaction between the mesh and the structure. Furthermore, the carrier material and cement provide a barrier which effectively reduces corrosion of the structure by sea water.

The mesh may be woven or knitted, or may be an expanded metal mesh. In the case of woven or knitted meshes, the copper strands may be interwoven with strands of other material, for example plastics. As an example, the copper strands may all extend in one direction and the plastic strands in the other direction.

In standard woven meshes, half the number of knuckles on one side of the mesh are generally disposed in one plane and the other half are disposed in a different plane, the planes being slightly spaced apart. Thus, considering both surfaces of the mesh, the knuckles lie in four different planes. It is preferred in the present embodiment that the knucles are disposed in a single plane so that all of them project from or are level with the front carrier surface 4. The formation of knuckles in a single plane may be achieved for example by rolling standard meshes or by a suitable weaving process.

During the life of the panel, copper from the mesh dissolves and in the panel of Figure 1 diffuses through the coating layer 6. However, the mesh presents a continuous run of copper alloy which is gradually leached away by the sea water. Thus, the life of the covering may be controlled by suitable choice of the alloy, the mesh size and the diameter of mesh wire, to suit a particular application.

The rate of dispersion of the copper may be further controlled by the application of an electric potential to the mesh, which controls the quantity of copper liberated. Optionally, the mesh may include strands of metal other than copper or copper alloy to control the rate of dispersion. For example, nickel may be interwoven to enhance the toxicity of the covering or zinc may be used to inhibit the toxicity.

The above-described covering has the advantages over copper or copper alloy sheets that it is relatively simple to attach to the structure, that electro-chemical reaction between the structure and the copper is avoided, that emission of the copper can be controlled, and that there is a cost advantage for selected mesh sizes.

WHAT WE CLAIM IS:—

1. A submersible or semi-submersible anti-fouling structure comprising a layer of carrier material and a mesh of copper or copper alloy embedded in said material, said mesh being exposed at the outer surface of said layer so as to be accessible to sea water for retarding or preventing marine growth on said structure.

2. A structure according to claim 1, wherein the area of exposed mesh is less than 50% of the total area of the outer surface of the layer.

3. A structure according to claim 2, wherein said area of exposed mesh is less than 35% of the total area of the outer surface of the layer.

4. A structure according to any of claims 1 to 3, wherein the area of exposure of the mesh is greater than about 13% of the total area of the outer surface of the layer.

5. A structure according to any of claims 1 to 4, wherein the mesh is coated with a layer of coating material which is permeable by sea water.

6. A structure according to claim 5, wherein the coating material is the same as the carrier material and is integral therewith.

7. A structure according to claim 5 or 6, wherein said coating material is a resin filled with a material which is insoluble in water and which enhances the permeability of said coating layer.

8. A structure according to any of claims 5 to 7, wherein said coating material is a resin filled with a material which is soluble in water and which can be leached out in water to provide a porous coating layer.

9. A structure according to any of claims 1 to 8, wherein the mesh is a woven mesh.

10. A structure according to any of claims 1 to 9, wherein the mesh size is in the range of 3 to 60 mesh/inch.

11. A structure according to claim 10, wherein the mesh size is greater than about 12 mesh/inch.

12. A structure according to claim 11, wherein the mesh size is about 20 mesh/inch.

13. A structure according to any of claims 1 to 12, wherein the mesh is formed

from wire having a diameter of from 0.05 mm to 1.5 mm.

14. A structure according to claim 8 of any of claims 9 to 13 as appendant to claim 8, wherein the mesh includes a plurality of strands of copper or copper alloy extending in one direction and strands of different material extending in the other direction.

15. A structure according to claim 14, wherein said strands of different material are of plastics material.

16. A structure according to claim 15, wherein said strands of different material are of metal other than copper or copper alloy.

17. A structure according to any of claims 1 to 16, wherein the mesh includes a copper alloy having small amounts of iron or other elements.

18. A structure according to any of claims 1 to 17, wherein the carrier material is a plastics material.

19. A structure according to claim 18, wherein the carrier material is polypropylene.

20. A structure according to claim 18, wherein the carrier material is polyester.

21. A structure according to claim 8 or any of claims 9 to 20 as appendant to claim 8, wherein the mesh has knuckles which are exposed at the outer surface of the carrier layer, all of said knuckles being in the same plane.

22. A structure according to any of claims 1 to 20, wherein the mesh has knuckles exposed at the outer surface, the distance between adjacent knuckles being from 0.25 to 7 mm.

23. A structure according to any of claims 1 to 22, wherein the covering comprises a plurality of juxtaposed panels.

24. A submersible or semi-submersible structure constructed and arranged substantially as herein described with reference to the accompanying drawings.

25. An anti-fouling panel for attachment to the surface of a submersible or semi-submersible structure, said panel comprising a layer of carrier material and a mesh of copper or copper alloy embedded in said material, said mesh being exposed at the outer surface of said layer so as to be accessible to sea water for retarding or preventing marine growth on said panel.

26. A panel according to claim 25, wherein the area of exposed mesh is less than 50% of the total surface area of the panel.

27. A panel according to claim 26, wherein the area of exposed mesh is less than 35% of the total surface area of the panel.

28. A panel according to any of claims 25 to 27, wherein the mesh size is 3 to 60 mesh/inch.

29. A panel according to claim 28, wherein the mesh size is greater than 12 mesh/inch.

30. A panel according to any of claims 25 to 28, wherein the area of exposure of the mesh is greater than about 13% of the total area of the panel.

31. A panel according to any of claims 25 to 30, wherein the mesh is coated with a layer of coating material which is permeable by sea water.

32. A panel according to claim 31, wherein the coating material is the same as the carrier material and is integral therewith.

33. A panel according to claim 31, wherein said coating material is a resin filled with a material which is insoluble in water and which enhances the permeability of said coating layer.

34. A panel according to claim 30, wherein said coating material is a resin filled with a material which is soluble in water and which can be leached out in water to provide a porous coating layer.

35. A panel according to any of claims 25 to 34, wherein the mesh is a woven mesh.

36. A panel according to any of claims 25 to 34, wherein the mesh size is in the range of 3 to 60 mesh/inch.

37. A panel according to claim 36, wherein the mesh size is greater than about 12 mesh/inch.

38. A panel according to claim 37, wherein the mesh size is about 20 mesh/inch.

39. A panel according to claim 35 or any of claims 36 to 38 as appendant to claim 35, wherein the mesh is formed from wire having a diameter of from 0.05 mm to 1.5 mm.

40. A panel according to claim 35 or any of claims 36 to 39 as appendant to claim 35, wherein the mesh includes a plurality of strands of copper or copper alloy extending in one direction and strands of different material extending in the other direction.

41. A panel according to claim 40, wherein said strands of different material are of plastics material.

42. A panel according to claim 41, wherein said strands of different material are of metal other than copper or copper alloy.

43. A panel according to any of claims 25 to 42, wherein the carrier material is a plastics material.

44. A panel according to claim 35 or any of claims 36 to 43 appendant to claim 35, wherein the mesh has knuckles which are exposed at the outer surface of the carrier layer, all of said knuckles being in the same plane.

45. A panel according to any of claims 25 to 43, wherein the mesh has knuckles exposed at the outer surface of the carrier layer, the distance between adjacent knuckles being from 0.25 to 7 mm.

46. An anti-fouling panel constructed and arranged substantially as herein described with reference to the accompanying drawings.

47. A method of covering a submersible or semi-submersible construction, comprising the steps of providing a layer of carrier material, coating the carrier material on the construction, embedding a mesh of copper or copper alloy in said material, said mesh including a woven mesh exposed at an outer surface of said material to sea water for retarding or preventing marine growth on the carrier material.

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